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(54) A method and apparatus for determining and updating a photoreceptor belt steering coefficient.

(57) An electrophotographic printing machine is provided having an endless photoreceptor belt (10) arranged to move in a predetermined path through a plurality of processing stations. The belt is steered by a motor (50) which changes the angle of one of a plurality of rollers (20) that support the belt. The apparatus is used in conjunction with a method for automatically and repeatedly measuring (64) and updating a steering coefficient (78) used in an automatic steering mode. The method includes centering the belt and finding the average "in" belt walk and "in" belt walk rate and the average "out" belt walk and "out" belt walk rate, in order to determine the steering control coefficient. The method allows for a single machine to have its steering coefficient repeatedly updated.

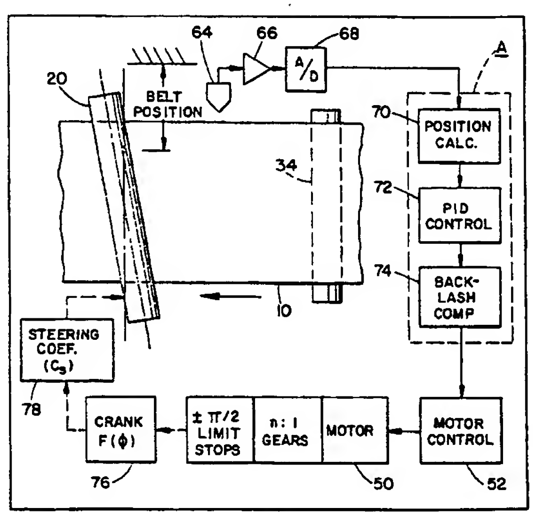

FIG. 6

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This invention relates generally to an electrophotographic printing machine, and more particularly concerns an improved method and apparatus for controlling the lateral movement of a moving belt.

In the process of electrophotographic printing, a photoreceptor belt is charged to a substantially uniform potential so as to sensitize the surface thereof. The charged portion of the belt is exposed to a light image of an original document being reproduced. Exposure of the charged belt selectively discharges the charge thereon in the irradiated areas. This records an electrostatic latent image on the belt corresponding to the informational areas contained within the original document. After the electrostatic latent image is recorded on the belt, the latent image is developed by bringing a developer mixture into contact therewith. Generally, the developer mixture comprises toner particles adhering triboelectrically to the carrier granules. The toner particles are attracted from the carrier granules to the latent image forming a toner powder image on the photoreceptor belt. The toner powder image is then transferred from the belt to a copy sheet. Finally, the copy sheet is heated to permanently affix the toner particles thereto in image configuration. This general approach was originally disclosed by Carlson in U.S. Patent No. 2,297,691 and has been further amplified and described by many related patents in the art.

Since the belt passes through many processing stations during the printing operation, lateral alignment thereof is critical and must be controlled within prescribed tolerances. As the belt passes through each of these processing stations, the location of the latent image must be precisely defined in order to optimize the operations relative to one another. If the position of the latent image deviates from processing station to processing station, copy quality may be significantly degraded. Hence, lateral movement of the photoreceptor belt must be minimized so that the belt moves in a predetermined path.

Similarly, document handling systems frequently employ belts to transport original documents to and from the exposure station. The lateral movement of belts used in document handling systems must also be controlled in order to insure the correct positioning of the original documents relative to the optical system of the exposure station.

There is a special need for precise control of a belt's lateral movement in a machine designed for multichromatic (color copy) image reproduction. In making multichromatic reproductions with an apparatus utilizing, for example, a moving charged photoreceptor belt, charge patterns corresponding to related color separation images may be formed in successive image frames of the belt. Such patterns are developed with pigmented marking particles to form transferable images. Each image is transferred sequentially to a respective receiver member whereby each image forms one of the several color separations for the multicolor reproduction. The sequential image transfer must be accomplished with high accuracy in order to obtain quality output of separations for faithful multicolor reproduction. In such color applications, transferable images generated from such successive "master" separations must be properly aligned for accurate superimposed registration during the creation of a multicolor composite print.

Therefore, during the production of such a separation, lateral movement of the belt during belt rotation must be closely controlled.

Ideally, if the photoreceptor belt was perfectly constructed and entrained about perfectly cylindrical rollers mounted and secured in an exactly parallel relationship with one another, the velocity vector of the belt would be substantially normal to the longitudinal axis of the roller and there would be no lateral walking of the belt. However, in actual practice, this is not feasible. Frequently, the velocity vector of the belt approaches the longitudinal axis or axis of rotation of the roller at an angle. This produces lateral movement of the belt relative to the roller. Alternatively, the axis of rotation of the roller may be tilted relative to the velocity vector of the belt. Under these circumstances, the belt will also move laterally. Thus, the belt must be tracked or controlled to regulate its lateral position.

Numerous methods of controlling the lateral movement of the photoreceptor belt maintain the belt within desired parameters have been proposed and implemented. Certain of these control schemes use a characteristic steering coefficient when determining proper correction procedures Generally, the characteristic steering coefficient is calculated for a prototype machine and this calculated coefficient is then transferred or used in a fixed manner by later manufactured machines. However, each manufactured machine will be different from any other machine, therefore the calculated steering coefficient of the prototype will not be ideally suited for each machine. Additionally, over time and/or when machine is serviced, characteristics of the machine will change. Thus, the use of a fixed characteristic steering coefficient will increase inaccuracies in the belt control scheme.

Accordingly, it is an object of the present invention to improve the system controlling the lateral movement of the photoreceptor belt employed in an electrophotographic printing machine including a method for repeatedly updating the steering coefficient.

Briefly stated, and in accordance with the present invention, there is provided an apparatus and method for improving the control over lateral alignment of a belt arranged to move in a predetermined path.

Pursuant to the features of the present inv ntion, the apparatus includes a roll arranged to support a

portion of the belt passing th reover and a means for rotatably supporting the roll. A motor is connected to the means which rotatably supports the roll and is used for orienting a roll in a desired direction. A further means is provided for automatically controlling operation of the motor in order to center the belt on the roll. To improve the control of the lateral alignment of the belt, a method used in cooperation with the apparatus is provided for determining an updated steering control gain or coefficient used to control motor operation used for adjusting the steering roll

The present invention is particularly suitable for use in an electrophotographic or electrostatographic printing machine.

An advantage of the present invention is the provision of an improved means for controlling the lateral movement of a moving belt in an electrophotographic printing machine.

In one embodiment of the present invention there is provided means for determining a photoreceptor belt steering coefficient during system initialization for a printing machine. This initializes system steering data for each particular machine during initial machine setup.

The present invention enables the periodic calibration of a photoreceptor belt steering coefficient for each printing machine. Therefore, even if the characteristics of components of a belt module of a particular machine change due to the duty of that machine which then changes the steering rate such periodic calibration will capture steering data and provide a more accurate steering coefficient for that particular machine.

A further feature of the present invention is the provision of a process for determining a photoreceptor belt steering coefficient for a particular machine, both for system initialization and for periodic recalibration.

In a particular embodiment of the invention, there is provided a method for automatically and repeatedly measuring and updating a steering coefficient used in an automatic steering mode, to maintain the endless photoreceptor belt of an electrophotographic printing machine within predetermined parameters, the method comprising engaging the automatic steering mode; steering the belt to a preset position; disengaging the automatic steering mode; turning the steering motor clockwise for N steps; measuring an average belt walk in and rate of belt walk in for X belt revolutions; reengaging the automatic steering mode; steering the belt back to the preset position; disengaging the automatic steering mode; turning the steering motor counterclockwise for N steps measuring an average belt walk out and rate of belt walk out for X belt revolutions; determining the steering coefficient.

The steering coefficient may be determined when the electrophotographic printing machine is powered.

The automatic steering mode may use a control scheme of at least one of (i) lead-lag series control, (ii) proportional + derivative control, and (iii) proportional integral derivative control.

The electrophotographic machine may use two rollers to move the belt, the step of determining the steering coefficient (Csteer) including applying the relationship,

$$\text{Csteer} = 0.2551\ \delta y \div \delta x \text{ wherein}$$

δy = average belt walk per belt revolution which is equal to 1/2 (dYin + dYout),

with dYin equal to the in belt walk rate and dYout equal to the out belt walk rate, and,

δx = calculated displacement of the steering yoke end displacement due to the number of steering steps and camming geometry.

Other objects and advantages of the present invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which:

FIG. 1 is a schematic elevational view depicting a belt module of a single pass high light printing machine incorporating the features of the present invention;

FIG. 2a is a schematic perspective view showing a belt module emphasizing the steering/tension roll and associated motor control and motor used in the printing machine of FIG 1;

FIG. 2b is a side schematic view emphasizing section G of FIG. 1;

FIG. 3 is a perspective view, partially broken-away of the steering/tension roll assembly;

FIG. 4 is a perspective view of a belt edge sensor;

FIG. 5 is a top plan view of a belt edge incorporating therein a "Z" sensor slot arrangement;

FIG. 6 is an active belt steering system block diagram;

FIG. 7 is a developed view of three rolls;

FIG. 8 is a flowchart showing the procedure for updating the steering coefficient; and,

FIG. 9 is a graphical representation of results for a procedure used to obtain a steering coefficient calculation according to the present invention.

For a general understanding of the illustrative electrophotographic printing machine incorporating the features of the present invention therein, reference is had to the drawings. In the drawings, like reference numerals have been used throughout to designate identical elements. FIG. 1 schematically depicts various components of an electrophotographic printing machine employing the belt support and steering mechanism of the present invention therein. Although the belt steering and support mechanism is particularly well adapted for use in an electrophotographic printing machine, it will become evident from the following discussion that it is equally well suited for use in a wide variety of office machines and other devices which employ a moving belt where the lateral

movement of the belt needs to be controlled, and is not n c ssarily limited in its application to the particular embodiment shown herein.

FIG. 1 discloses a single pass high light color printing machine. The printing machine employs a belt **10** having a photoreceptor surface **12** deposited on a conductive substrate **14**. Preferably, photoreceptor surface **12** can be made from a selenium alloy with conductive substrate **14** being made from an aluminum alloy. Belt **10** moves in the direction of arrow **16** to advance successive portions of photoreceptor surface **12** sequentially through the various processing stations disposed about the path of movement thereof. Belt **10** is entrained about stripper roll **18**, steering/tension roll **20**, and drive roll **22**. Steering/tension roll **20** is resiliently mounted. Belt end guides or flanges are positioned on opposed sides thereof and define a passageway through which belt **10** passes. Drive roll **22** is in engagement with belt **10** and advances belt **10** in the direction of arrow **16**. Drive roll **22** is rotated by motor **24** coupled thereto by suitable means, such as a belt.

A blower system can be connected to stripper roll **18** and steering/tension roll **20**. If desired, both stripper roll **18** and steering/tension roll **20** can have small holes in the circumferential surface thereof coupled to an interior chamber. The blower system furnishes pressurized fluid, i.e. a compressible gas such as air, into the interior chamber. The fluid egresses from the interior chamber through the apertures to form a fluid film between belt **10** and the respective roll, i.e. stripper roll **18** and steering/tension roll **20**. In this manner, the fluid film at least partially supports the belt as it passes over the respective roll diminishing friction therebetween.

With continued reference to FIG. 1, stations **A**, **B**, **C**, and **D** are constructed to sequentially produce red, blue, green, and black images respectively. Each station **A**, **B**, **C**, and **D** separately charges, exposes, and develops images on belt **10**. In the charging procedure, the photoreceptor surface **12** of belt **10** is charged to a relatively high, substantially uniform potential Next, a digital image of the original document being copied, is exposed on belt **10** through an LED image bar. The LED image bar is part of each of the stations. The charged photoreceptor surface **12** is selectively discharged by the light image of the original document. This records an electrostatic latent image on photoreceptor surface **12** which corresponds to selected informational areas contained within the original document.

Thereafter, during the development procedure, the developer mix of the particular station is brought into contact with the latent image recorded on photoreceptor surface **12** of belt **10**. The developer mix comprises carrier granules having toner particles adhering triboelectrically to the selected informational areas. The latent image attracts the toner particles from the carrier granules forming a toner powder image on photoreceptor surface **12** of belt **10**.

The toner powder images recorded by the stations **A**, **B**, **C**, and **D** on photoreceptor surface **12** of belt **10** are then transported to transfer station **E**. At transfer station **E**, a sheet of support material **26** is positioned in contact with the toner powder images deposited on photoreceptor surface **12**. The sheet of support material is advanced to the transfer station by a sheet feeding apparatus **28**. Preferably, the sheet feeding apparatus **28** includes a feed roll contacting the uppermost sheet of a stack of sheets of support material. The feed roll rotates so as to advance the uppermost sheet from the stack. The sheet of support material **26** is moved into contact with the photoreceptor surface **12** of belt **10** in a timed sequence so that the developed powder images contact the sheet of support material at transfer station **E**. Transfer station **E** includes a corona generating device which applies a spray of ions to the backside of sheet **26**. This attracts the toner powder image from photoreceptor surface **12** to sheet **26**. After transfer, the sheet continues to move in the direction of arrow **16** and is separated from belt **10** by neutralizing the charge causing sheet **26** to adhere to belt **10**. The sheet is advanced from belt **10** to a fusing station **F** which permanently affixes the transferred toner powder image to sheet **26** In this manner, the toner powder image is permanently affixed to sheet **26**. After fusing, the sheet **26** is advanced for removal from the printing machine.

Invariably, after the sheet of support material is separated from photoreceptor surface **12** of belt **10**, some residual particles remain adhering thereto. These residual particles are removed from photoreceptor surface **12** at cleaning station **G** Cleaning station **G** includes rotatably mounted fibrous cleaner rolls/brushes **30** in contact with photoreceptor surface **12** of belt **10**. The particles are cleaned from photoreceptor surface **12** by the rotation of cleaner rolls/brushes **30** in contact therewith Subsequent to cleaning, a discharge lamp floods photoreceptor surface **12** with light to dissipate any residual electrostatic charge remaining thereon prior to the charging thereof for next successive imaging cycle. Support rolls **32** and isolation rolls **34** are included to provide support of the belt **10** throughout its length.

It is believed that the foregoing description is sufficient for purposes of the present application to illustrate the general operation of an electrophotographic printing machine.

Referring now to the specific subject matter of th present invention, FIG. 2a depicts a structure for maintaining belt **10** substantially in lateral alignment during the movement thereof in the direction of arrow **16**, including structure which makes it possible to obtain and implement updated steering coefficients.

Steering/tension roll **20** is supported pivotably in

yoke **40**. Yoke **40** includes a U-shaped member **42** having steering/tension roll **20** mounted fixedly therein. A rod **44**, having pin joint **44a**, extends from the center of Ushaped member **42** and is mounted rotatably in a fixed frame. Preferably, rod **44** is supported in a suitable bearing **45** minimizing friction during the pivoting thereof. The longitudinal or steering axis of rod **44** is substantially normal to the longitudinal axis of roll **20**. In this manner, roll **20** pivots in the direction of arrow **46** about the axis of rotation of rod **44** This steering axis of rotation controls the lateral displacement of the belt. Preferably, a tension spring **48** or the like resiliently biases or pushes the steering/tension roll **20** away from the stripper roll **18** and drive roll **22** to maintain a tension on the belt **10**.

Steering motor **50** is attached to steering/tension roll **20** The motor may be a stepping motor or other suitable motor. The motor **50** has a cam **50a**, preferably a linear cam, mounted on the motor shaft, with the cam bearing on block **50b** which is positioned as part of yoke **40**. Rotation of the motor causes the yoke to pivot in a desired manner through the cam, block arrangement. Controlled motor operation is accomplished by motor controller **52**. A restraining spring **54** biases the steering/tension roll **20** to counteract the camming action from the opposite end.

FIG. 2b provides a more detailed view of section H of FIG. 1 showing locations of the steering/tension roll **20**, cam **50a**, isolation rolls **34**, belt **10**, and a sensor **54**. As can be seen in this Figure, movement of steering/tension roll **20** causes the angle of belt **10**, between the isolation rolls **34** and the steering/tension roll **20**, to be altered. The Figure discloses the steering/tension roll and cam at their nominal positions, and extended or rotated positions.

FIG. 3 shows the yoke arrangement of FIG. 2a in a cut-away view, having the belt omitted for improved clarity. It is to be noted that the motor may include a gear train and there may be other mechanical linkage between the cam and yoke.

FIGS. 4 and 5 disclose a manner of sensing belt movement in a preferred embodiment. A belt edge sensor **54** is positioned in the printing device to have the belt **10** pass through a slot opening **56**. Illumination light (e.g. LED) from wires **58** illuminates the slot **56** in a desired manner Analog lateral position signal wires **60** from a detector (not shown) are positioned on the underside of slot **56** As the belt **10** passes through slot **56**, light is partially blocked and this information is transmitted from analog lateral position signal wires **60** to the detector element (not shown). The output analog voltage sensed by detector (not shown) is proportional to belt lateral position from a predetermined reference. The analog signal is subsequently conditioned, digitized, and sent to further control circuitry for adjustment of the belt position. In one embodiment, the control circuitry would be in the motor controller **52**. In other embodiments, it could be sent to a control computer (not shown).

FIG. 5 shows a detailed view of a diagonal line target on the belt **10** This diagonal line target is in th form of a "Z-hole" pattern **62**. As the "Z-hole" pattern on the belt moves with the belt under the belt edge sensor **54**, the sensor traces a path across it. Using the "Z-hole" pattern, the belt position can accurately be determined. It is to be appreciated that other line target patterns such as a "N-hole" pattern can be implemented.

The "Z-hole" pattern sensor is described in EP-A-0,494,105.

The detection scheme shown in FIGS. 4 and 5 can be implemented in an active belt steering arrangement as shown generally in FIG. 6. The system includes a belt **10**, steering/tension roll **20**, and isolation rolls **34** and structure to support the rolls and belt. Lateral position sensing may be accomplished using a Z-hole sensor **62**, or as shown in FIG 6, by an arrangement including a belt edge sensor **64**, a signal amplifier **66**, and an A-D converter **68**. In an automatic steering mode, using an edge sensor, a position calculation block **70** receives the sampled data from the A-D converter to calculate the belt position. A Proportional Integral Derivative control (PID) **72** implements the position data obtained from the sampled data of the sensor to provide control signals for compensating undesirable belt movement. A backlash compensation circuit **74** is provided within the automatic steering mode A to reduce undesirable backlash in the movements of the belt and motor. The motor control **52** provides the developed correction signals from the Proportional Integral Derivative (PID) control **72** and supplies these signals to the motor **50**. If desired, a known double eccentric steering roll crank **76** can be implemented, similar to the cam block arrangement shown in FIG. 2, in conjunction with the motor **50** to move the steering roll **20** in an appropriate position. A steering coefficient **78** is used in providing the proper movement compensation necessary in the system

A characteristic steering coefficient of printing machines and other machines using a moving belt arrangement cannot be reliably predicted by calculation. Additionally, the coefficient is known to be sensitive to small deformations of the machine structure, such as may occur when the belt subassembly is pulled out for service and then replaced. Changes in the coefficient may also occur as the dimensions of particular belts **10** will vary. Prior to the present invention, the characteristic steering coefficient for a printing machine had been experimentally deduced on prototypes and that value was then projected to the entire population of subsequently produced machines. Therefore, it has been previously only possible to gain a general approximation of the actual value for any particular machine. This procedure compromises the accuracy and stability of the entire

steering control system.

The present invention provides the capability of repeatedly measuring the steering coefficient while the belt is in place, even aft r machines have be n sent to final work sites, and after belts have been changed.

FIG. 8 provides a flowchart for updating a steering coefficient. The operations represented by the flowchart may be controlled by the motor control **52** or by a system computer (not shown). Initially, as snown in block **80**, the automatic steering mode A is engaged in order to steer the belt to a preset point **82**. When the belt is at the preset point, the automatic steering mode control is disabled **84**. The steering motor is then turned clockwise for a predetermined amount of steps **86** and the average belt walk (Yin) and the belt walk rate (dYin) in distance per belt revolution is measured for a predetermined number of belt revolutions **88**, e.g., 4 revolutions (see FIG 9). At this point, the automatic steering mode is re-engaged **90** and the belt is steered back to the preset point **92**. The automatic steering control is again disabled **94** and the steering motor is turned counterclockwise for a predetermined amount of steps **96** and the average belt walk (Yout) and walk rate (dYout) is measured for a predetermined number of belt revolutions **98**. It is to be appreciated that the determining of the "out" walk may be done prior to determining of the "in" walk. Also, any desired number of belt revolutions can be used although the numbers should be identical. Using the above-obtained data, an updated steering control gain or coefficient is determined **100**.

FIG. 9 provides an example of graphical representation sensed edge data obtainable while the belt is drifting inward or outward. With continuing reference to FIG. 9, a procedure to determine the steering coefficient includes:

1. turning the steering roll to one side to remove possible backlash.
2. turning the steering roll in the same direction for N steps; lock the steering roll; run the belt for 3 revolutions; put belt edge data in an array Y(3n) at a fixed sample rate which is associate with a process encoder clock at n samples per belt revolution.
3. calculating the slope B(i), intercept A(i) of linear regression for each of n data sets consisting of Y(i), Y(n + 1), Y(2n + 1); find the belt walk rate (distance per revolution per N steering steps) by taking average of n slope data where: Yin = $(\Sigma(B(i)) \div n$.
4. calculating a correlation coefficient CC(i) for each set of Y(i), Y(n + 1), Y(2n + 1).
5. repeating steps 1 through 4 to find Yout.
6 average belt walk rate C_{steer} (steering coefficient) can then be determined by taking average of Yin and Yout where: C_{steer} = (Yin + Yout) ÷ 2.

It is important to have the value of B(1)..B(m)..B(n) to be close. If any CC(i) is far from ± 1, it is likely the steering system is not stable.

In an idealized two roll system, the steering coefficient based on a specific two roll model would be found by:

Csteer = 0.2551 $\delta y \div \delta x$ wherein

Csteer = Steering Coefficient (CS)

δy = average belt walk per belt revolution; (equal to 1/2 (dYin + dYout)) assuming the walk rate is approximately the same near the set point; and,

δx = the calculated yoke end displacement due to the number of steering steps.

Upon obtaining the updated coefficient of steering, the machine can then be switched back to the automatic steering control mode using the new coefficient. The obtained steering coefficient is then used in a known control scheme for subsequent belt steering control. By implementing this method, a greater degree of accuracy is obtained in controlling belt movement.

It is to be appreciated that although the present application suggests updating the steering coefficient in a machine using a PID control scheme, the updating of the steering coefficient can be implemented in other control schemes including Proportional + Derivative (P + D) or leadlag series filtered control.

FIG. 7 shows a top view of a three roll system with the steering roll **20** being adjusted to compensate for belt movement.

From the above-discussion, it is evident that there has been provided in accordance with the present invention, an apparatus and method for improving the control over compensation for lateral movement of a photoreceptor belt such that the belt moves in a predetermined path.

Claims

1. An apparatus for controlling the lateral alignment of a belt (10) arranged to move in a predetermined path, comprising:

   a roll (20) arranged to support a portion of the belt passing thereover;

   a means (40) for rotatably supporting said roll;

   a motor (50), connected to said means for rotatably supporting said roll for orienting said roll in a desired direction; and,

   a means (52) for automatically controlling an operation of said motor in order to center the belt on said roll.

2. The apparatus of claim 1 wherein said means for automatically controlling comprises:

   a means (64,66,68) for acquiring belt tracking data;

a means (70,72,74,52) for actuating said motor (50) based on the belt tracking data acquired.

3. The apparatus of claim 1 or claim 2 further comprising a means for initializing said means for automatically controlling, said means for initializing comprising:
a means for determining a tilt range of said roll;
a means for determining a linear displacement of said means for rotatably supporting the roll;
a means for determining the number of revolutions of said roll;
a means for steering said motor clockwise for N steps;
a means for steering said motor counterclockwise for N steps; and,
a means for setting a steering coefficient of said motor.

4. The apparatus of any one of claims 1 to 3 wherein said means for rotatably supporting said roll comprises:
a yoke (40) on which said roll (20) is rotatably mounted;
a spindle (44) to which said yoke is secured; and,
a frame on which said spindle is mounted.

5. The apparatus of claims 4, including:
a cam follower (50b) secured to an end of said yoke (40); and
a cam (50a) in operative engagement with said cam follower (50b);
said motor (50) being connected to said cam (50a), for operating on said cam follower (50b) and pivoting said yoke on said spindle (44) and hence orienting said roll (20) in a desired direction.

6. An electrophotographic printing machine of the type having an endless photoreceptor belt arranged to move in a predetermined path through a plurality of processing stations disposed therealong, including the apparatus of any one of claims 1 to 5 for controlling the lateral alignment of the photoreceptor belt.

7. An apparatus for controlling operations upon a web, comprising:
a means for sensing an edge pattern of said web, said edge pattern comprising a cross-track position and an in-track position of said web;
a means for generating signals representing sensed edge pattern data;
a means for storing said edge pattern data;
a means for comparing said sensed edge data; and,
a means for steering said belt to the desired edge position from several belt revolutions when the sensed edge position exceeds a predetermined allowed limit value.

8. The apparatus of claim 7 wherein said means for steering comprises:
a roll arranged to support a portion of said belt passing thereover;
a means for rotatably supporting said roll; and,
a motor, connected to said means for rotatably supporting said roll for orienting said roll in a desired direction.

9. A method for initializing a steering control of a web moving along a path, the web being subject to lateral movement in a direction transverse to the direction of movement of the web along the path, the method comprising the steps of:
steering the belt by means of a steering motor to a preset position;
turning the steering motor clockwise for N steps;
measuring an average belt walk and rate of belt walk for X belt revolutions;
steering the belt back to the preset position;
turning the steering motor counterclockwise for N steps;
measuring an average belt walk and rate of belt walk for X belt revolutions;
determining a steering control gain.

10. A method for automatically and repeatedly measuring and updating a steering coefficient used in an automatic steering mode, to maintain the endless photoreceptor belt of an electrophotographic printing machine within predetermined parameters, the method comprising:
engaging the automatic steering mode;
steering the belt to a preset position;
disengaging the automatic steering mode;
turning the steering motor clockwise for N steps;
measuring an average belt walk in and rate of belt walk in for X belt revolutions;
reengaging the automatic steering mode;
steering the belt back to the preset position;
disengaging the automatic steering mode;
turning the steering motor counterclockwise for N steps;
measuring an average belt walk out and

rate of belt walk out for X belt revolutions;

determining the steering coeffici nt.

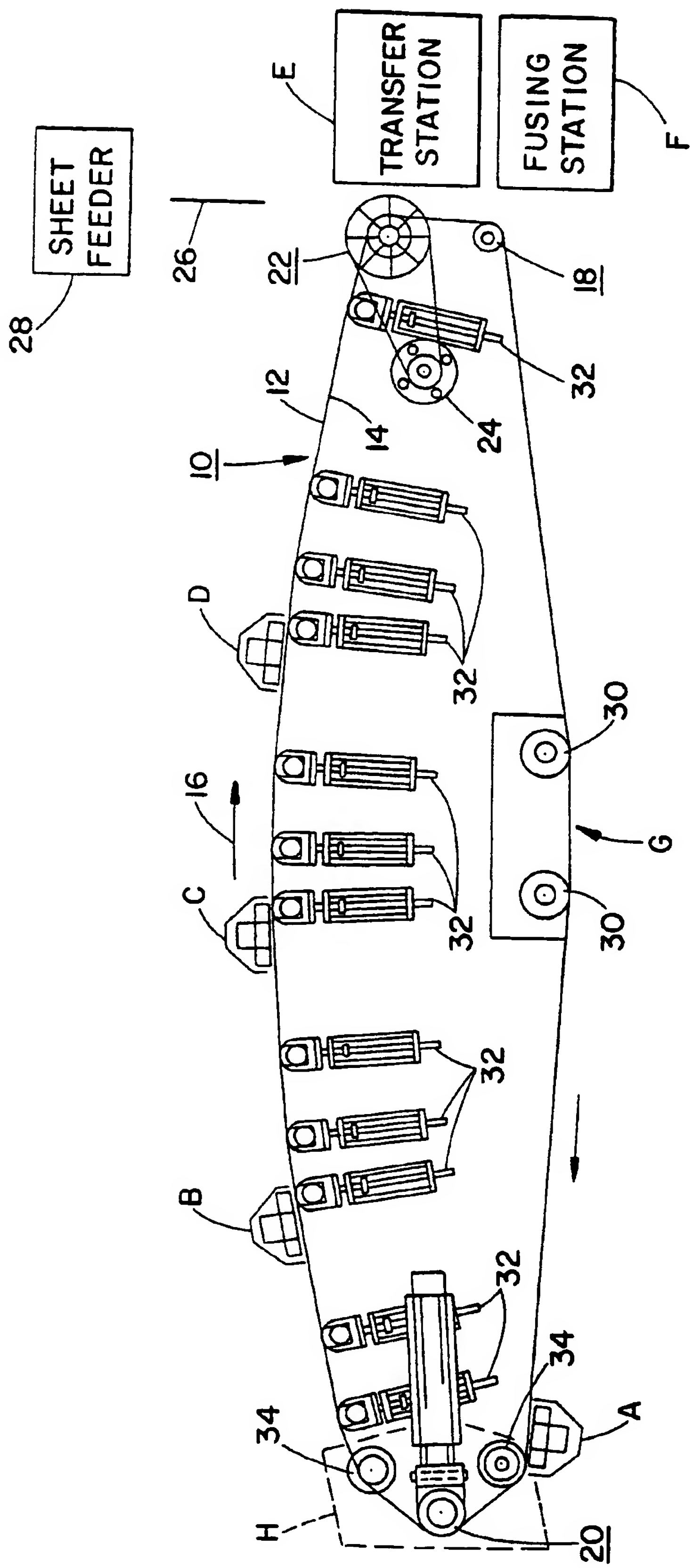
SHEET FEEDER
TRANSFER STATION
FUSING STATION
28
26
22
18
E
F
10
12
14
24
32
D
C
B
A
16
30
G
34
H
20

FIG. 1

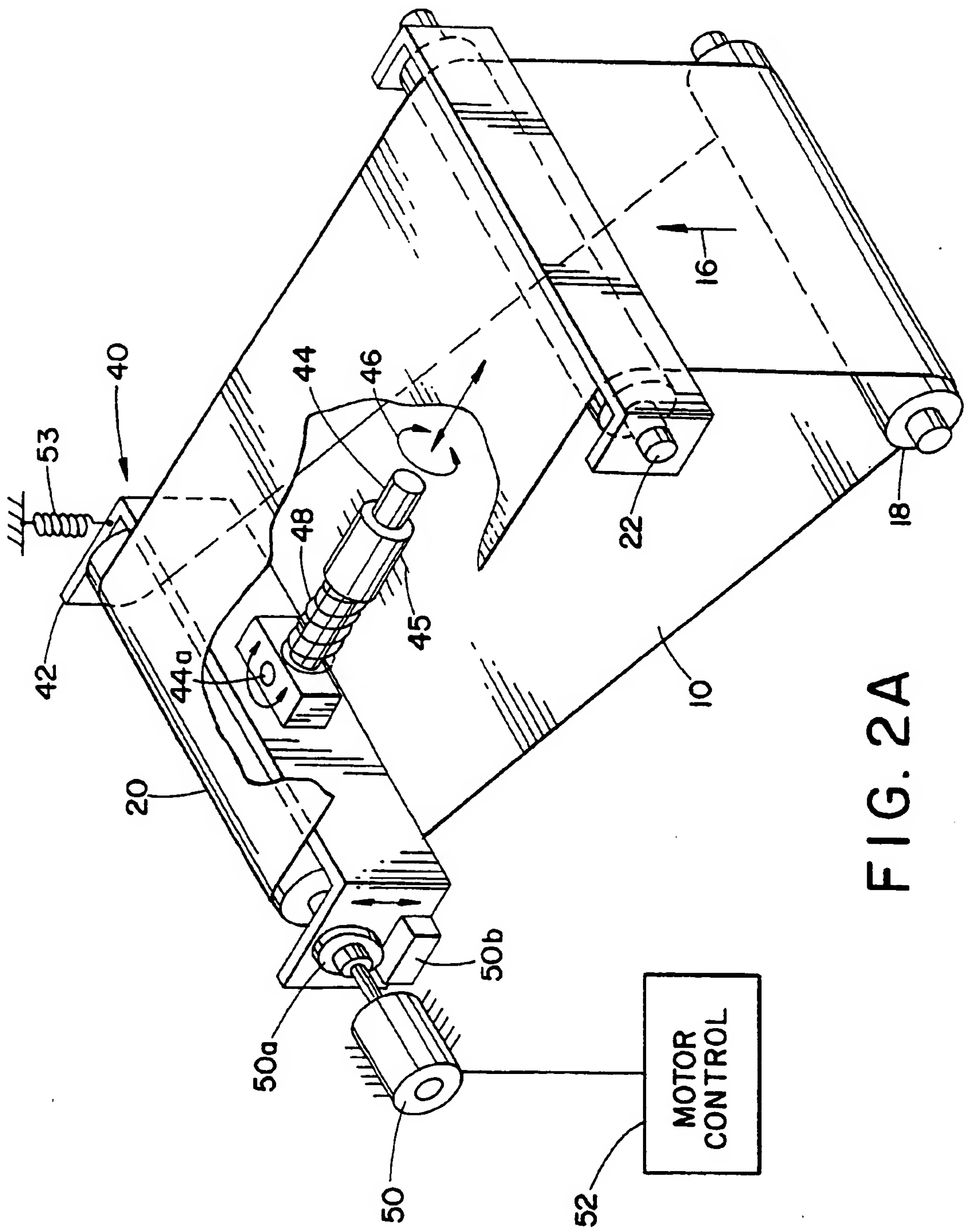

FIG. 2A

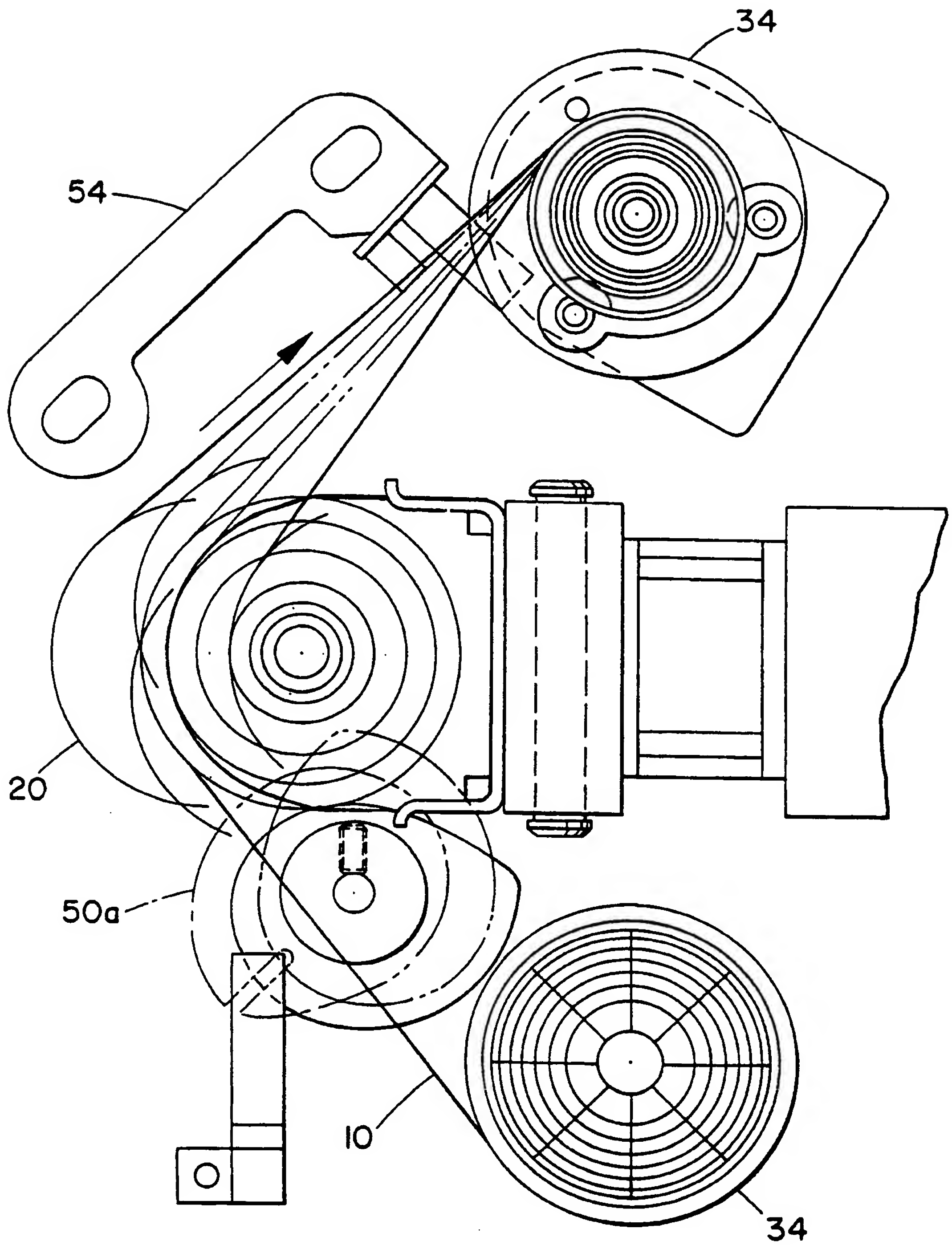

FIG. 2B

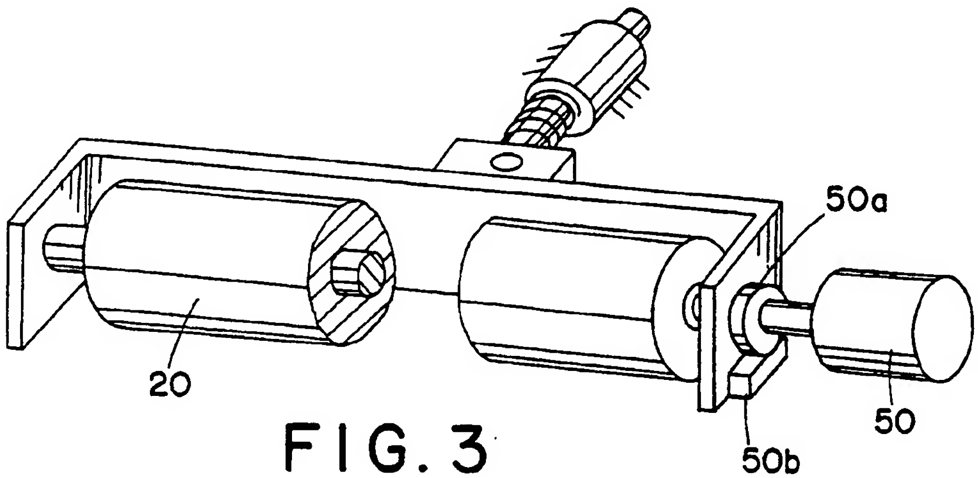

FIG. 3

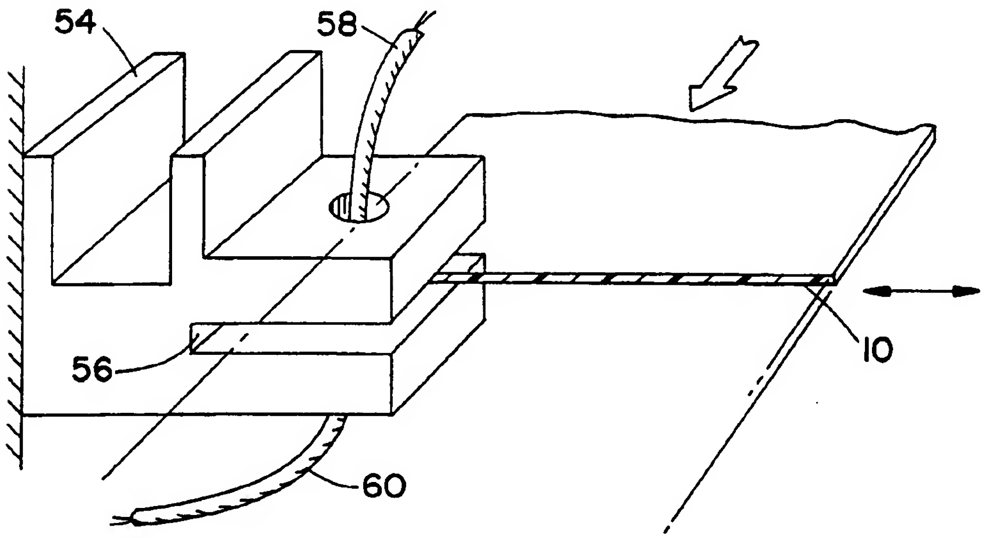

FIG. 4

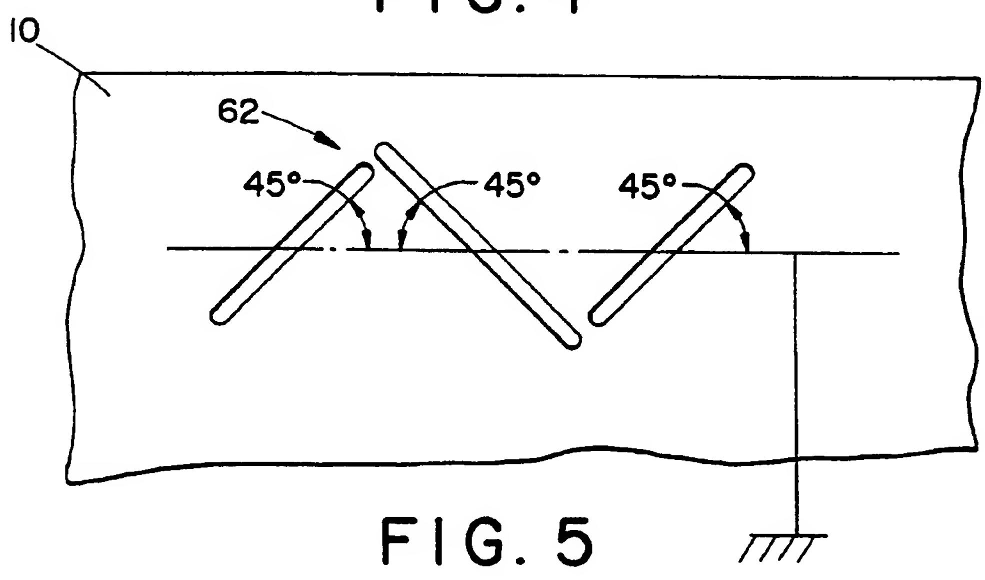

FIG. 5

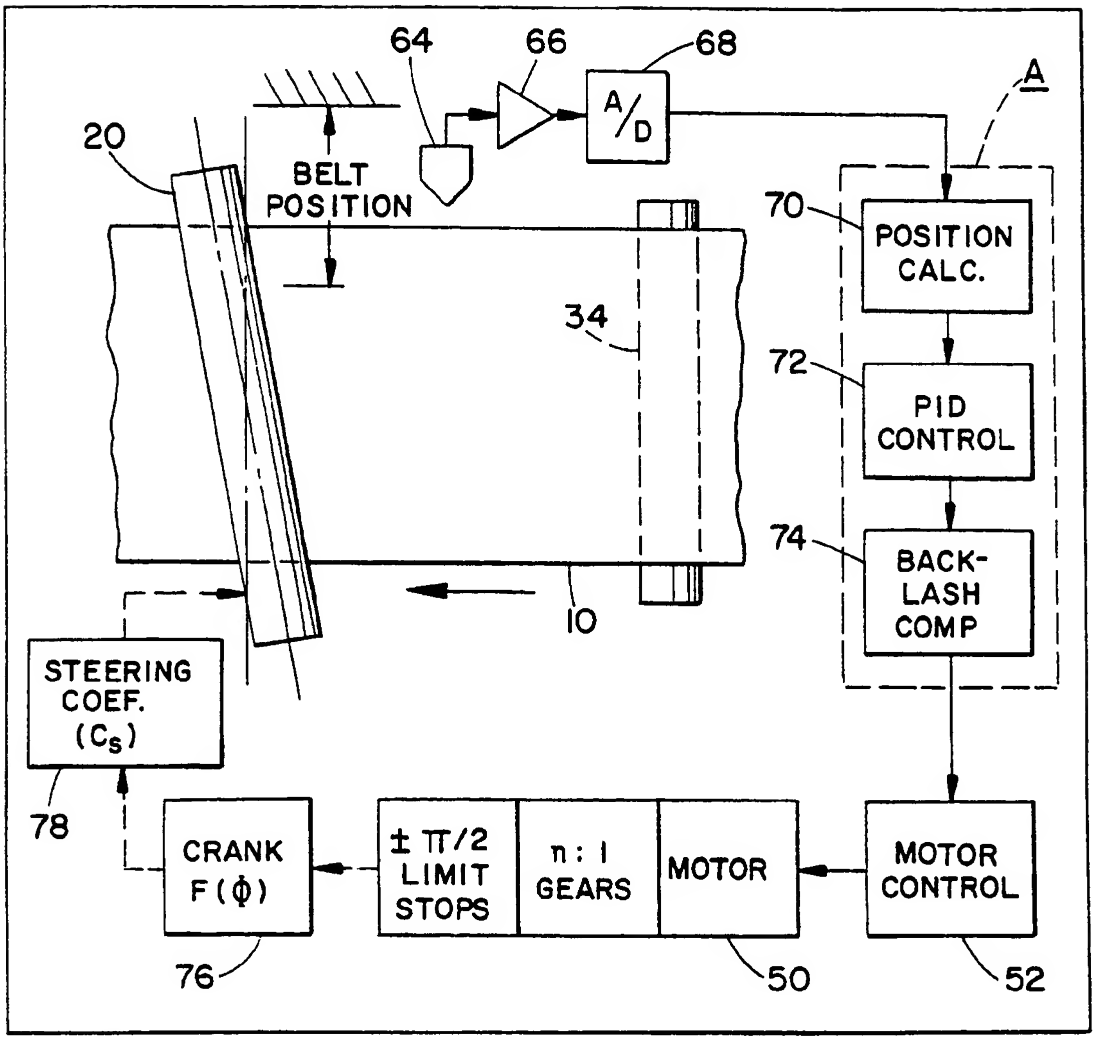
64
66
68
A/D
A
20
BELT POSITION
70
POSITION CALC.
34
72
PID CONTROL
74
BACK-LASH COMP
10
STEERING COEF. (C_s)
78
CRANK F(ϕ)
± π/2 LIMIT STOPS
n : 1 GEARS
MOTOR
MOTOR CONTROL
76
50
52

FIG.6

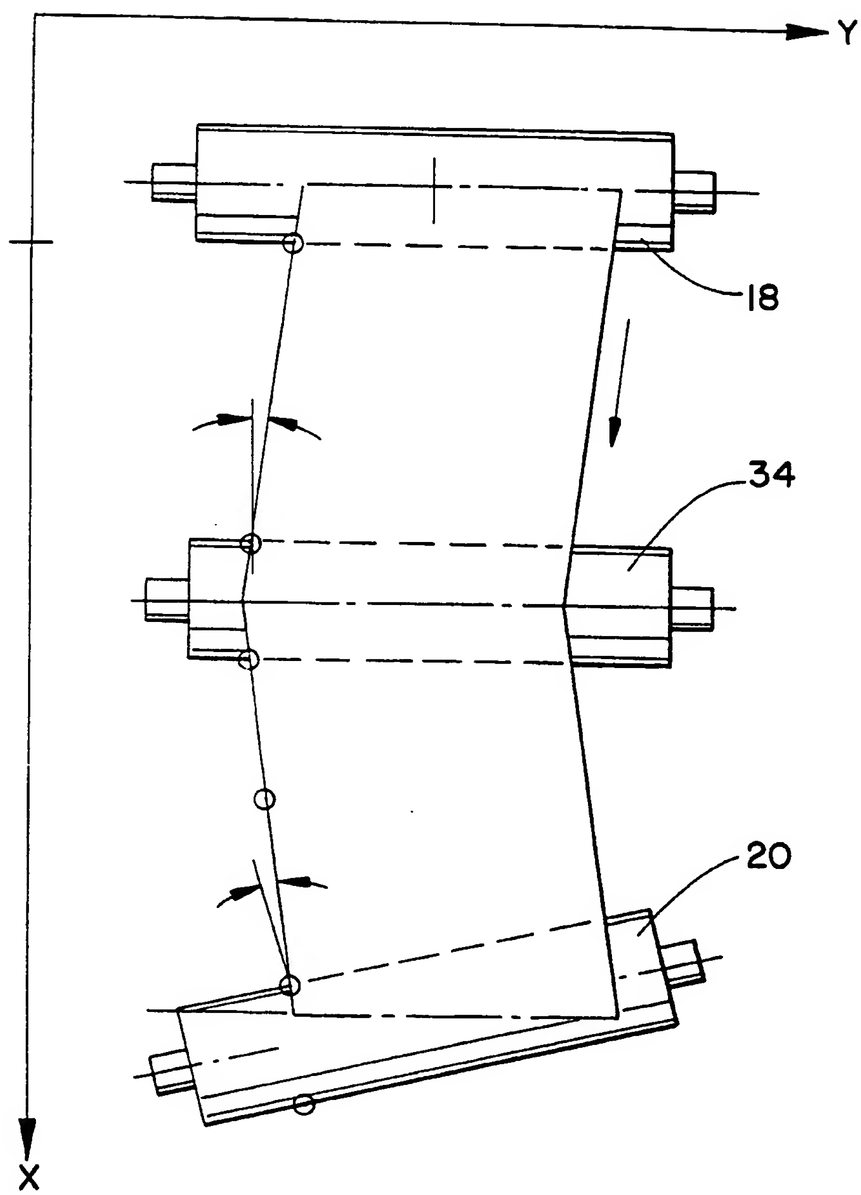

FIG. 7

COEFFICIENT UPDATE

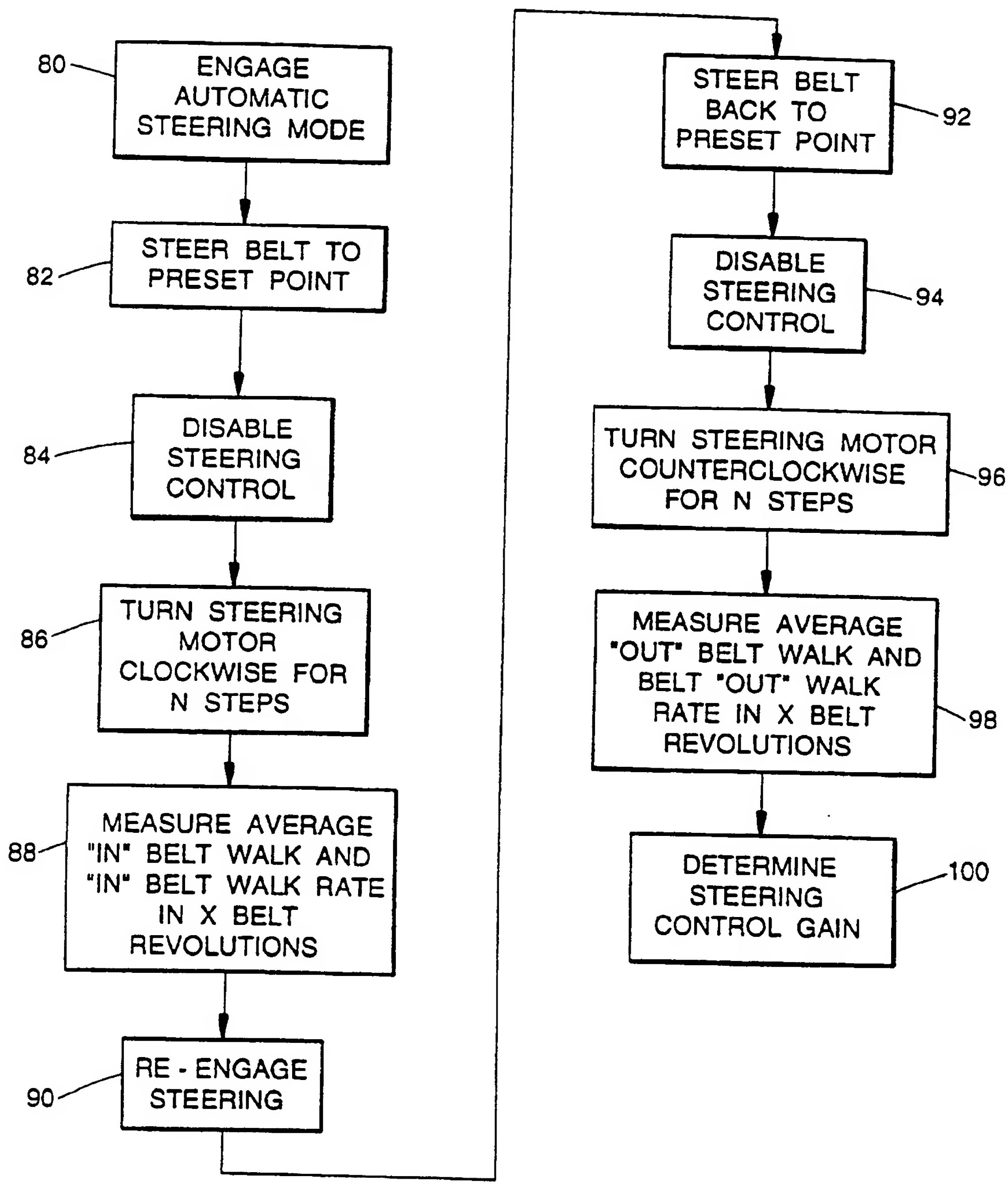

FIG. 8

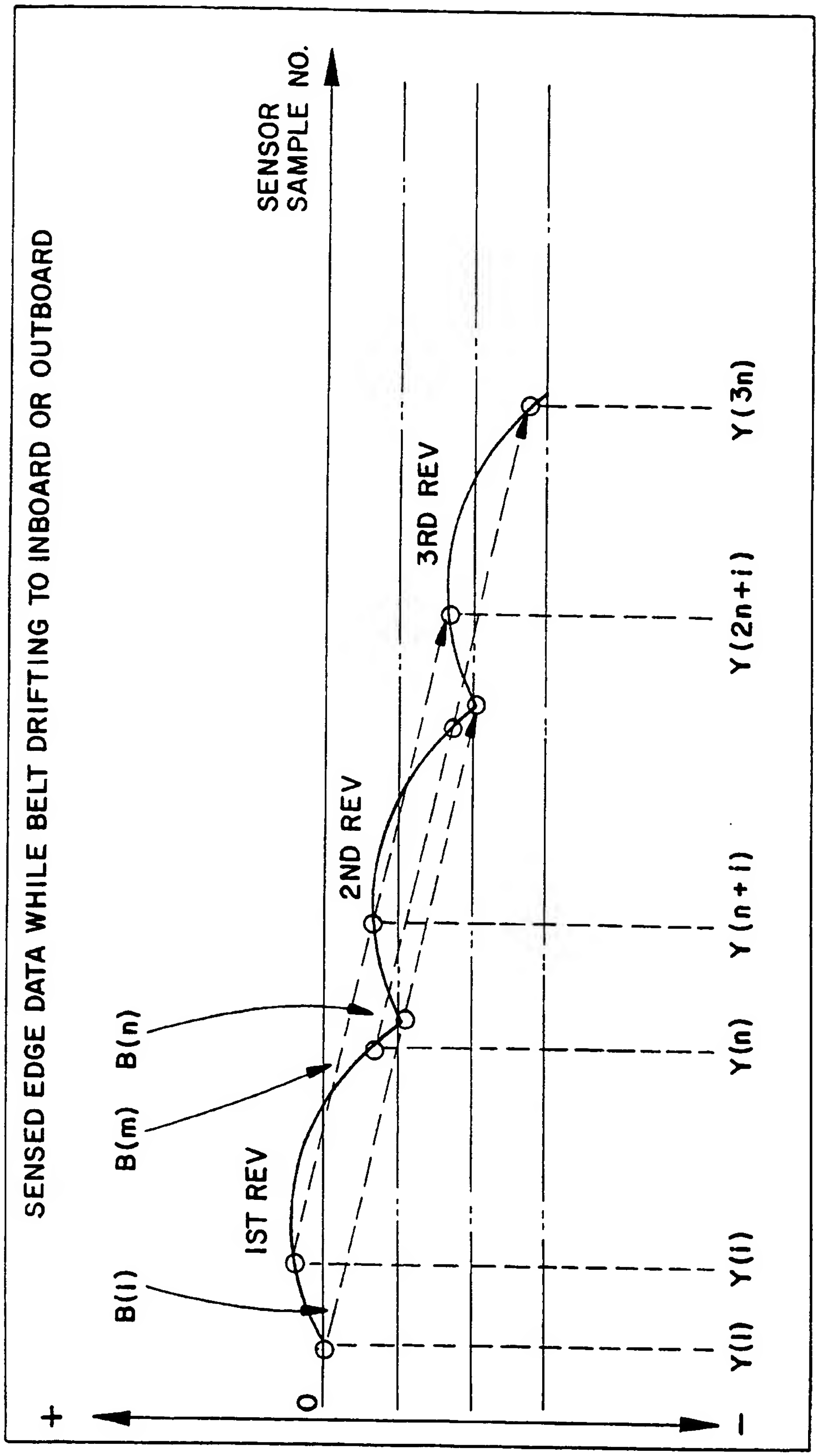
SENSED EDGE DATA WHILE BELT DRIFTING TO INBOARD OR OUTBOARD
SENSOR SAMPLE NO.
+
O
−
B(I)
B(m)
B(n)
IST REV
2ND REV
3RD REV
Y(I)
Y(I)
Y(n)
Y(n+I)
Y(2n+I)
Y(3n)

FIG. 9